MILITARY SPECIFICATION

CAPACITORS, FIXED, CERAMIC, MULTILAYER, HIGH VOLTAGE (GENERAL PURPOSE) ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER), general purpose, ceramic multilayer high voltage capacitors for use in applications where appreciable variations in capacitance with respect to temperature, voltage, frequency, and life can be tolerated (BR and BZ characteristics) (see 6.1), or in critical frequency determining applications, timing circuits, and other applications where absolute stability is required (BP characteristic). Capacitors covered by this specification have failure rate levels ranging from 1.0 to 0.001 percent per 1,000 hours. These failure rate levels are established at a 60 percent confidence level and maintained at a 10 percent producer's risk and are based on life tests performed at maximum rated voltage at maximum rated temperature. A part per million (PPM) quality system is used for documenting and reporting the average outgoing quality of capacitors supplied to this specification. Statistical process control (SPC) techniques are required in the manufacturing process to minimize variation in production of capacitors supplied to the requirements of this specification.

1.2 Classification. Capacitors covered by this specification should be classified by the style, as specified (see 3.1).

1.2.1 Part or Identifying Number (PIN). Capacitors specified herein (see 3.1) should be identified by a PIN which should consist of the basic number of the military specification and a coded number. The coded number should provide information concerning the characteristic, specification sheet number, capacitance, capacitance tolerance, and failure rate level. The PIN should be in the following form with the coded number derived as indicated:

M49467	R	01	101	K	M
Military specification indicating MIL-C-49467	Characteristic (1.2.1.1)	Military specification sheet number (indicating MIL-C-49467/1)	Capacitance (1.2.1.2)	Capacitance tolerance (1.2.1.3)	Failure rate level (1.2.1.4)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Laboratory Command, ATTN: SLCET-R-S, Fort Monmouth, NJ 07703-5000 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5910

1.2.1.1 Characteristic. The characteristic refers to the voltage-temperature limits of the capacitor. The first letter (B) (not shown) identifies the rated temperature range of -55°C to +125°C. The second letter indicates the voltage temperature limits as shown in table I.

TABLE I. Characteristic.

Symbol	Capacitance change with reference to +25°C		
	Steps A to D inclusive of table VIII	Rated voltage	Steps E and G inclusive of table VIII
P	0 ±30 PPM/°C	100%	0 ±30 PPM/°C
R	±15%	100%	+15, -40%
Z	±15%	40%	+15, -25%
		60%	+15, -40%

1.2.1.2 Capacitance. The nominal capacitance value, expressed in picofarads (pF) is identified by a three digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow.

1.2.1.3 Capacitance tolerance. The capacitance tolerance is identified by a single letter in accordance with table II.

TABLE II. Capacitance tolerance.

Symbol	Capacitance tolerance
J	±5%
K	±10%
M	±20%

1.2.1.4 Failure rate level. The failure rate level should be as specified in table III.

TABLE III. FR level (established at a 90 percent confidence level).

Symbol	FR level
	Percent/1,000 hours
M	1.0
P	0.1
R	0.01
S	0.001

2. APPLICABLE DOCUMENTS

2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATONS

MILITARY

MIL-F-14256	-	Flux, Soldering, Liquid (Rosin Base).
MIL-C-39028	-	Capacitors, Packaging Of.
MIL-I-46058	-	Insulating Compound, Electrical (For Coating. Printed Circuit Assemblies).

(See supplement for list of associated specification sheets.)

STANDARDS

MILITARY

MIL-STD-202	-	Test Methods For Electronic and Electrical Component Parts.
MIL-STD-690	-	Failure Rate Sampling Plans and Procedures.
MIL-STD-790	-	Reliability Assurance Program for Electronic Parts Specifications.
MIL-STD-810	-	Environmental Test Methods.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA-554	-	Assessment of Outgoing Nonconforming Levels in Parts Per Million (PPM).
EIA-557	-	Statistical Process Control Systems.

(Application for copies should be addressed to the Electronic Industries Association, Engineering Department, 1722 Eye Street, NW, Washington, D.C. 20006.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.4 and 6.3).

3.3 Reliability and quality.

3.3.1 Reliability. Reliability of capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements as specified in MIL-STD-790 and MIL-STD-690 with details as specified in 4.1.2, 4.4.4.1, and 4.5.

3.3.2 Quality.

3.3.2.1 Statistical process control. The manufacturer shall implement and use statistical process control techniques in the manufacturing process for parts covered by this specification. The SPC program shall be developed and maintained in accordance with EIA-557. The SPC program shall be documented and maintained as part of the overall reliability assurance program as specified in MIL-STD-790. The implementation date for statistical process control shall be 12 months from the date of the manufacturer's QPL listing. Processes for application of SPC techniques should include but are not limited to:

a. Raw material mixing and blending
b. Dielectric sheet manufacture
c. Stacking and electrode printing
d. Laminating and dicing
e. Chip firing
f. Termination
g. Encapsulation
h. Packaging

3.3.2.2 Quality levels. The quality of lots that have been subject to and have passed the subgroup 1 100 percent screening inspections of the group A inspection shall be established and maintained in accordance with 4.6.1.2.2 and EIA-554, method B. Individual PPM defect levels (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5) shall be established based on the tests prescribed in the subgroup 3 tests of the group A inspections. The defect level for PPM-2 shall be less than 100 PPM. Data shall not be excluded from the appropriate PPM calculation unless specifically authorized by the qualifying activity. Guidance for exclusion of data is specified in EIA-554.

3.3.2.3 Noncompliance. The manufacturer shall notify the qualifying activity when the 100 PPM level is reached or exceeded for PPM-2. The manufacturer shall provide sufficient information to the qualifying activity documenting the causes of the problem and what corrective action is being taken. Failure to correct this problem shall be the basis for removal of the effected product from the QPL.

3.4 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the capacitors to meet the performance requirements of the specification. Acceptance or approval of any constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.4.1 Insulating and impregnating compounds. Insulating and impregnating compounds, including resins, varnishes, waxes, and the like, shall be suitable for each particular application. Compounds shall preserve the electrical characteristics of the insulation to which they are applied.

3.5 Design and construction. Capacitors shall be of the design, construction, and physical dimensions as specified (see 3.1).

3.6 Thermal shock and voltage conditioning. When tested as specified in 4.7.2, capacitors shall withstand the extremes of high and low temperature without visible damage and meet the following requirements:

Dielectric withstanding voltage (at +25°C): As specified in 3.9. Shall be performed after the thermal shock test only.

Insulation resistance (at +25°C): Shall not be less than the value shown on figure 1.

Insulation resistance (at elevated ambient temperature): Shall not be less than the value shown on figure 1.

Dissipation factor (at +25°C): Shall not exceed the value as specified.

Capacitance (at +25°C): Shall be within the tolerance as specified.

3.7 Capacitance. When measured as specified in 4.7.3, the capacitance shall be within the specified tolerance.

3.8 Dissipation factor. When determined as specified in 4.7.4, the dissipation factor shall not exceed the percent as specified.

3.9 Dielectric withstanding voltage. Capacitors shall withstand direct current (dc) potential as specified in 4.7.5 without damage or breakdown.

3.10 Partial discharge (corona). When measured as specified in 4.7.6, the corona inception voltage (CIV) at the 100 pC level shall not be less than 0.42×(dc rated V) rms volts.

3.11 Resistance to soldering heat. When tested as specified in 4.7.7, capacitors shall meet the following requirements:

Insulation resistance at +25°C: Not less than the initial +25°C requirement.

Capacitance: Shall not change more than -1.0 percent to +6.0 percent of initial measured value (BR and BZ characteristics) or -1.0 percent to +2.0 percent or 0.5 pF, whichever is greater, of initial measured value (BP characteristic).

Dissipation factor: Shall not exceed the initial limits.

3.12 Insulation resistance. When measured as specified in 4.7.8, the insulation resistance shall be not less than the value specified on figure 1.

3.13 Solderability. When capacitors are tested as specified in 4.7.9, the dipped surface of the leads shall be at least 95 percent covered with a new, smooth, solder coating. The remaining 5 percent may contain only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability, and pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.14 Voltage-temperature limits. The capacitance change over the range of temperatures as specified in 4.7.10 shall not exceed the limits as specified in table I. The capacitance value obtained in step C of table VIII shall be considered as the reference point.

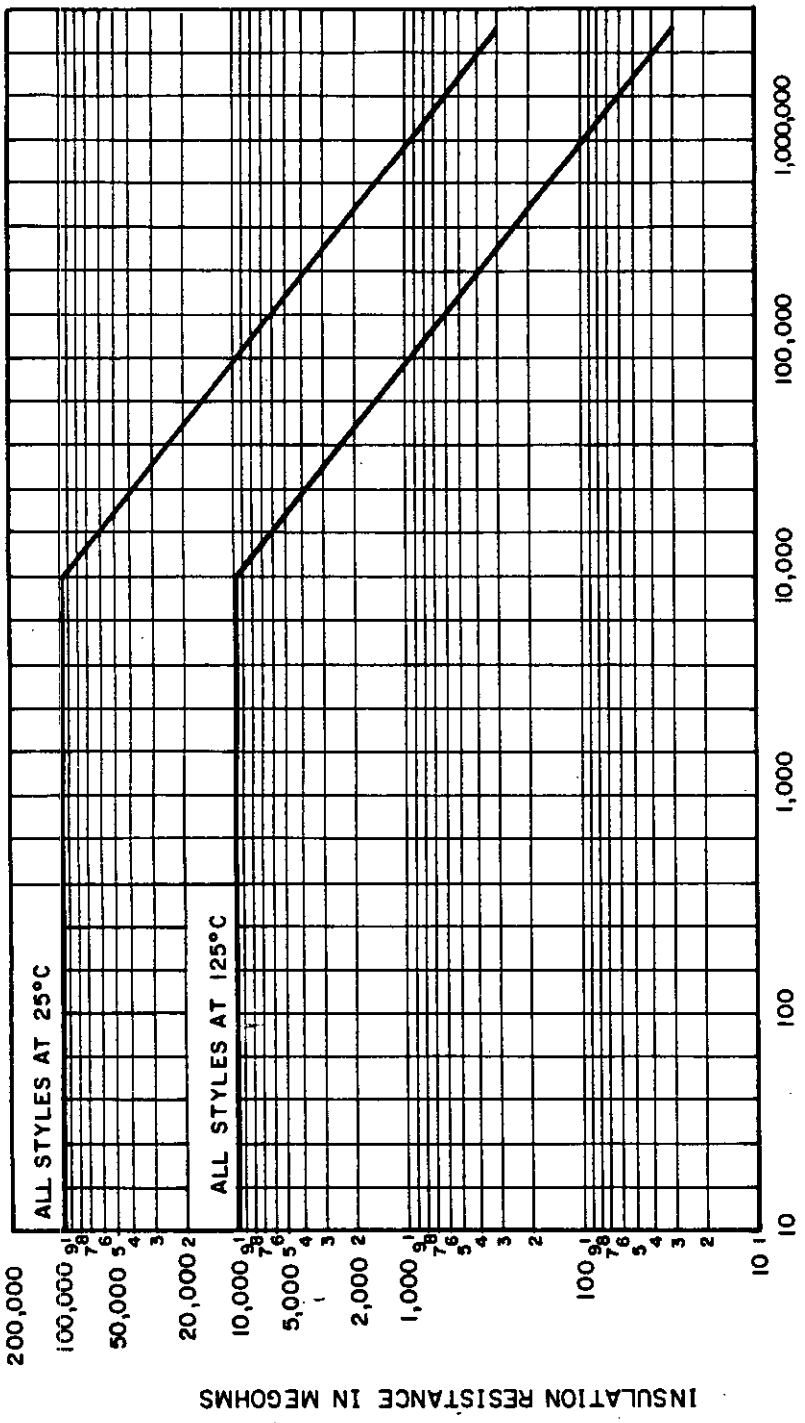


FIGURE 1. Insulation resistance versus capacitance.

3.15 Vibration, high frequency. When capacitors are tested as specified in 4.7.11, there shall be no intermittent contact of 0.5 millisecond (ms) or greater duration, open-circuiting or short-circuiting, or evidence of mechanical damage.

3.16 Immersion. When tested as specified in 4.7.12, capacitors shall meet the following requirements:

Visual examination: No mechanical damage. Marking shall remain legible.

Dielectric withstanding voltage: As specified in 3.9.

Insulation resistance: Not less than the value specified.

Capacitance: Change not to exceed ±10 percent of initial measured value (BR and BZ characteristics) or ±0.5 percent or 5 pF, whichever is greater, of initial measured value (BP characteristic).

Dissipation factor: Shall not exceed initial limits.

3.17 Shock, specified pulse. When tested as specified in 4.7.13, there shall be no momentary or intermittent contact of 0.5 ms or greater duration, open-circuiting or short-circuiting, or other evidence of breakdown, arcing, and mechanical damage.

3.18 Terminal strength (applicable unless otherwise specified, see 3.1). When capacitors are tested as specified in 4.7.14, there shall be no loosening or rupturing of the terminals.

3.19 Moisture resistance. When tested as specified in 4.7.15, capacitors shall meet the following requirements:

Visual examination: No mechanical damage. Marking shall remain legible.

Dielectric withstanding voltage: As specified in 3.9.

Insulation resistance: Not less than 90 percent of the initial +25°C requirement.

Capacitance: Change not to exceed ±10 percent of initial measured value (BR and BZ characteristics) or ±0.5 percent or 5 pF, whichever is greater, of initial measured value (BP characteristic).

3.20 Fungus. The manufacturer shall certify that all materials are fungus resistant or shall perform the test as specified in 4.7.16. When capacitors are tested as specified in 4.7.16, examination shall not disclose evidence of fungus growth on the external surface.

3.21 Resistance to solvents. When capacitors are tested as specified in 4.7.17, there shall be no evidence of mechanical damage and the marking shall remain legible.

INK: Capacitors marked with ink (INK) or laser etched and back filled with ink shall be examined in qualification inspection and group B.

OLM: Capacitors over-coated and then laser marked (OLM) shall be examined in qualification inspection and group B.

NLM: Capacitors not over-coated prior to laser marking (NLM) and etched directly into the bodies shall be examined in qualification inspection and group B.

3.22 Life (at elevated ambient temperature). When tested as specified in 4.7.18, capacitors shall meet the following requirements:

Insulation resistance (at elevated ambient temperature): Shall not be less than the value as specified (see figure 1).

Visual examination: No mechanical damage. Marking shall remain legible.

Insulation resistance (at +25°C): Shall not be less than the value as specified (see figure 1).

Capacitance: Shall not change more than ±0.3 percent or 0.3 pF, whichever is greater, of the initial reading (BP characteristic) or ±15 percent of the initial reading (BR and BZ characteristics).

Dissipation factor: Shall not exceed ±0.2 percent of the initial reading (BP characteristic) or ±3.0 percent of the initial reading (BR and BZ characteristics).

3.23 Low temperature storage. When tested as specified in 4.7.19, capacitors shall withstand the low temperature as specified without evidence of mechanical damage.

3.24 Radiographic inspection (swaged leads only). When capacitors are tested as specified in 4.7.20, radiographic examination shall not disclose evidence of improperly made connections, substandard soldering or structural weakness, or attached solder particles or slivers.

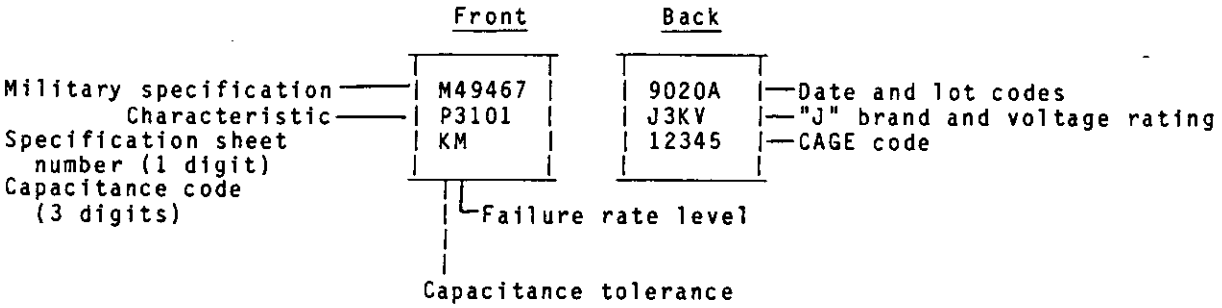
3.25 Marking. Capacitors shall be marked as specified herein. Paper labels shall not be used. Other markings which in any way interfere with, obscure, or confuse those specified herein, are prohibited. Each capacitor shall be legibly marked with smear-resistant ink that will withstand the environmental conditions as specified herein. At the option of the manufacturer, capacitors may be laser marked. The marking shall remain legible after all tests.

3.25.1 Marking legibility (laser marking only). When tested as specified in 4.7.1.1, the marking shall remain legible.

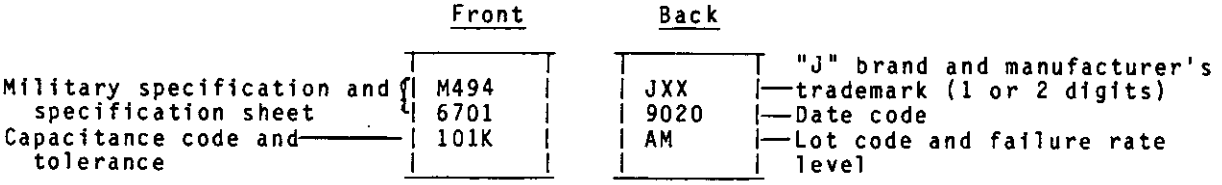
3.25.2 JAN and J marking. The United States Government has adopted, and is exercising legitimate control over, the certification marks "JAN" and "J", respectively, to indicate electrical equipment, namely, resistors, capacitors, electron tubes and the like, procured by, or manufactured for use by, or for the Government in accordance with standard Government specifications. Accordingly, capacitors procured to, and meeting all of, the criteria specified herein and in applicable specification sheets shall bear the certification mark "JAN", except that capacitors too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be located on the first line above or below the PIN. Capacitors furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and the applicable specification sheets, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all capacitors represented by the sample. The United States Government has obtained certificate of registration number 504,860 for the certification mark "JAN".

3.25.3 Full marking. Unless otherwise specified (see 3.1), capacitors shall be marked with the "JAN" or "J" marking, PIN, date code and lot number, manufacturer's name (not trademark) or commercial and Government entity (CAGE), voltage, capacitance, and capacitance tolerance. There shall be no space between the symbols which comprise the PIN. The date code and lot number shall consist of the year, week, and lot code. For example: The third week of 1990 would be 9003 . At the option of the manufacturer, the marking may be placed on one side of the capacitor, in the same order as shown in the example. Additional marking is permitted, following the required marking or on the opposite side, as long as it conforms to 3.25.

EXAMPLE:



3.25.4 Marking of smaller capacitors. Capacitors with a height or width of less than .300 (7.62) may, at the option of the manufacturer, be marked in accordance with the following example:



3.25.5 Supplying to higher failure rate levels. A manufacturer may supply to all higher failure rate levels than to which he is qualified. Parts qualified and marked to lower failure rate levels, with procuring agency approval, are substitutable for higher failure rate levels, and shall not be remarked unless specified in the contract or acquisition document (see 6.2).

3.25.6 Supplying to looser capacitance tolerance and lower rated voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage, with procuring agency approval, are substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values, such as case size, characteristic, and leads are the same. The substitutable parts shall not be remarked unless specified in the contract or acquisition document (see 6.2).

3.26 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality when using 2x minimum to 4x maximum magnification. External leads shall not exhibit cuts, nicks, or scrapes exceeding 10 percent of the diameter of the leads. Within .050 (1.27 mm) of the body of the component, 10 percent of the surface area of the leads may exhibit bare base metal. These capacitors are not expected to be solderable within .050 (1.27 mm) of the case.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order the contractor may use his own or any other facilities suitable for the performance of the inpsection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Reliability assurance program. A reliablity assurance program shall be established and maintained in accordance with MIL-STD-790. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

4.1.3 Statistical process control (SPC). An SPC program shall be established and maintained in accordance with EIA-557. Evidence of such compliance shall be verified by the qualifying activity as a prerequisite for qualification and retention of qualification.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

a. Qualification inspection (see 4.4).
b. Verification of qualification (see 4.5).
c. Quality conformance inspection (see 4.6).

4.3 Inspection conditions and methods.

4.3.1 Conditions. Unless otherwise specified herein, all inspections shall be made in accordance with the "GENERAL REQUIRMENTS" of MIL-STD-202 except relative humidity shall not exceed 75 percent. Accuracy of all test voltage measurements shall be within ±2.0 percent of the specified voltage.

4.3.2 Methods.

4.3.2.1 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at +25°C ±3°C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.3 Power supply. The power supply used for life testing shall have a regulation of ±2 percent or less of the specified test voltage.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3), on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be as specified to qualification inpsection shall be as specified in table IV and in appendix A. Each capacitor style shall be qualified separately.

4.4.1.1 Sample selection. Samples shall be selected in accordance with 4.6.1.1.1 and shall be representative of the highest capacitance value.

4.4.2 Test routine. Sample units shall be subjected to the qualification inspection as specified in table IV, in the order shown. All sample units shall be subjected to the inspection of groups I and II. The sample shall then be divided as specified in table IV for groups III through VII, and subjected to the tests for their particular group. Samples which have been selected to be submitted to the life test shall be subjected to rated conditions. The decision as to whether or not the product is to be included on the qualified products list shall be made at the conclusion of the 2000-hour life test. Each unit shall be continued on for a total of 10,000 hours.

4.4.3 Failures. Failures in excess of those allowed in table IV shall be cause for refusal to grant qualification approval.

4.4.4 Failure rate level and quality level verification.

4.4.4.1 Failure rate (FR) qualification. Failure rate qualification shall be in accordance with the general and detailed requirements of MIL-STD-690 with the following details:

a. Procedure I - Qualification at the initial failure rate level. Level "M" (1.0 percent/1,000 hours) of FRSP-60 shall apply. Sample units which have been subjected to the qualification inspection as specified in group VII, table IV shall be continued on test as specified in 4.7.18.

b. Procedure II - Extension of qualification to lower failure rate levels. To extend qualification to the 0.01 percent/1,000 hours "R", and 0.001 percent/1,000 hours "S" failure rate levels, data from 2 or more styles of similar construction may be combined.

c. Procedure III - Maintenance of failure rate level qualification. Maintenace period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification.

4.4.4.2 Quality level verification. The manufacturer is responsible for establishing a quality system to verify the PPM defect level of lots that are subjected to subgroup 3 tests of the group A inspections. All capacitor styles may be combined for PPM calculations. The PPM defect level shall be based on a 6-month moving average. The manufacturer shall verify and report individual PPM categories (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5).

TABLE IV. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted 1/
Group I				
Thermal shock and voltage conditioning	3.6	4.7.2	All units	Not applicable
Partial discharge	3.10	4.7.6	All units	Not applicable
Radiographic inspection (swaged leads only)	3.24	4.7.20	All units (when applicable)	Not applicable
Group II 2/				
Visual and mechanical examination: Material, design, construction, and workmanship	3.4, 3.4.1, 3.5, 3.26	4.7.1	250 3/	1
Physical dimensions and marking	3.1 and 3.25 to 3.25.3, inclusive			
Capacitance	3.7	4.7.3		
Dissipation factor	3.8	4.7.4		
Dielectric withstanding voltage	3.9	4.7.5		
Insulation resistance	3.12	4.7.8		
Group III				
Low temperature storage	3.23	4.7.19	6	1
Solderability	3.13	4.7.9		
Marking legibility (laser marking only)	3.25.1	4.7.1.1		
Group IV				
Voltage-temperature limits	3.14	4.7.10	18	1
Vibration, high frequency	3.15	4.7.11		
Immersion	3.16	4.7.12		
Group V				1
Shock, specified pulse	3.17	4.7.13	18	1
Terminal strength 4/	3.18	4.7.14		
Resistance to soldering heat	3.11	4.7.7		
Moisture resistance	3.19	4.7 15		
Group VI				
Fungus 5/	3.20	4.7.16	6	1
Resistance to solvents	3.21	4.7.17	6 (12)	
Group VII				
Life (at elevated ambient temperature)	3.22	4.7.18	195	1
Partial discharge	3.10	4.7.6		

See footnotes on next page.

1/ A sample unit having one or more defects will be charged as a single defective.
2/ Nondestructive examinations and tests.
3/ One additional sample unit is included in each sample of 250 sample units to permit substitution for the permitted defective in group II.
4/ Applicable, unless otherwise specified (see 3.1).
5/ Certification of fungus resistance may be substituted for testing. Only 244 samples are needed if certification is given for fungus (see 3.20).

4.5 Verification of qualification. Every 6 months, the manufacturer shall compile a summary of the results of quality conformance inspections and, where applicable, extended failure rate test data, in the form of a verification of qualification report, and forward it to the qualifying activity as the basis of continued qualification approval. In addition to the periodic submission of failure rate test data, the manufacturer shall immediately notify the qualifying activity whenever the failure rate data indicates that the manufacturer has failed to maintain his qualified failure rate level. Continuation shall be based on evidence that, over the 6 month period, the following has been met:

a. Verification by the qualifying activity that the manufacturer meets the requirements of MIL-STD-790.

b. The manufacturer has not modified the design of the item.

c. The specification requirements for the item have not been amended so far as to affect the character of the item.

d. Lot rejection for group A inspection does not exceed 10 percent or one lot, whichever is greater.

e. The requirements for group B inspection are met.

f. The records of all failure rate tests combined substantiate that the 1.0 percent/1,000 hours, or 0.1 percent/1,000 hours "P" failure rate levels have been maintained or that the manufacturer continues to meet the 0.01 percent/1,000 hours, or 0.001 percent/1000 hours failure rate level for which qualified although the total component hours of testing does not, as yet, meet the requirements of 4.4.4.1c.

g. The manufacturer shall provide documentation to the qualifying activity pertaining to PPM calculations including numbers of part types tested, individual PPM defect categories (i.e., PPM-2 and PPM-3), and the overall PPM defect rate (PPM-5). All capacitor styles may be combined for PPM calculations.

If group B requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, the forwarding of the verification of qualification report may be delayed until within 30 days after completion of retesting of the periodic quality conformance tests. In this case, the qualifying activity shall be notified of this condition within the time that the orginal verification of qualification report was due. All reports shall be certified by a responsible company official. The qualifying activity shall be contacted for the report format.

If a group B test requires a comparison of "post-test" readings with initial readings (delta measurements), the verification of qualification summary shall include the maximum and minimum delta changes for each inspection lot. For life testing, delta C readings shall be reported at each interval in which readings are taken.

Failure to submit the report within 30 days after the end of each 6-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 6-month period that the inspection data indicates failure of the qualified product to meet the requirements of the specification.

4.5.1 Records. Test records shall be in accordance with the format in MIL-STD-690.

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors of one sytle and voltage-temperature limit, from the same production line or lines, produced under essentially the same conditions and offered for inspection during a single work week. Each lot shall be kept separate from every other lot. The sample from the lot shall be representative of the highest capacitance values in the lot. All sample units belonging to a lot shall be identified by means of a code symbol (either letters or numbers, at the option of the manufacturer). All styles may be combined for failure rate levels "R" and "S".

4.6.1.1.2 Production lot. A production lot shall consist of all capacitors of the same style, voltage rating, nominal capacitance value, and voltage-temperature characteristic. The manufacture of all parts in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.

4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table V, and shall be made on the same set of sample units in the order shown.

4.6.1.2.1 Subgroups 1 and 2 tests. Subgroup 1 and subgroup 2 (swaged leads only) tests shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of these subgroups shall be removed from the lot. If, during the 100 percent inspection, screening requires that more than 10 percent of the capacitors be discarded, the entire lot shall be rejected.

4.6.1.2.2 Subgroup 3 tests (PPM categories).

4.6.1.2.2.1 Sampling plans. Subgroup 3 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 3 shall be selected in accordance with table VI based on the size of the inspection lot (Note: Larger samples may be inspected by the manufacturer to calculate PPM; however, rejection of the lot shall be based on one or more defects). In the event of one or more failures the lot shall be rejected. The equipment used to perform the subgroup 3 tests may be the same as those used in the subgoups 1 and 2 100 percent tests; the operators, however, shall not be the same.

TABLE V. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
Subgroup 1			
Thermal shock	3.6	4.7.2.1	100% inspection
Dielectric withstanding voltage	3.9	4.7.5	100% inspection
Voltage conditioning	3.6	4.7.2.2	100% inspection
Partial discharge	3.10	4.7.6	100% inspection
Subgroup 2			
Radiographic inspection (swaged leads only)	3.24	4.7.20	100% inspection (when applicable)
Subgroup 3 (PPM)			
Capacitance (PPM-2)	3.7	4.7.3	See table VI
Dissipation factor (PPM-2)	3.8	4.7.4	
Dielectric withstanding voltage (PPM-2)	3.9	4.7.5	
Insulation resistance (PPM-2)	3.12	4.7.8	
Mechanical examination			
Design and construction (PPM-3) (dimensions only)	3.5		
Subgroup 4			
Visual examination			
Material	3.4 and 3.4.1	4.7.1	13 samples 0 failure
Marking 1/	3.25		
Workmanship	3.26		
Subgroup 5			
Solderability 2/	3.13	4.7.9	13 samples 0 failure

1/ Marking defects are based on visual examination only. Any subsequent electrical defects shall not be used as a basis for determining marking defects.
2/ Voltage conditioning rejected parts may be used. Parts subjected to this test shall not be delivered.

TABLE VI. Sampling plans for PPM categories.

Lot size	Sample size
1-125	100 percent
126-3200	125
3201-10,000	200
10,001-35,000	315
35,001-150,000	500
150,001-500,000	800
500,001-up	1250

4.6.1.2.2.2 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defective in the sample and any defectives found removed from the lot. A new sample of parts shall then be randomly selected in accordance with table VI. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

4.6.1.2.2.3 PPM calculations. The PPM calculations shall be based on the results of the first sample check as prescribed in 4.6.1.2.2.1. Calculations and data exclusion shall be in accordance with EIA-554. (Note: PPM calculations shall not use data on the second sample submission.)

4.6.1.2.3 Subgroups 4 and 5 tests. Subgroups 4 and 5 shall be performed on an inspection lot basis. The sampling procedure shall be as specified in table V.

4.6.1.2.3.1 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroups 4 and 5 may be offered for acceptance only if the manufacturer inspects all units in the lot for those quality characteristics found defective in the sample and, after removing all defective units found, reinspects the lot using the sampling procedure specified in table V. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification. Resubmitted lots shall be kept separate from new lots, and shall be identified as resubmitted lots.

4.6.2 Periodic inspection. Periodic inspection shall consist of group B inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.3), delivery of products which have passed group A inspection shall not be delayed pending the results of these periodic inspections.

4.6.2.1 Group B inspection. Group B inspection shall consist of the tests specified in table VII in the order shown, and shall be performed on sample units selected from lots that have passed group A inspection. Test data obtained therefrom shall be reviewed as part of the complete verification of qualification. Capacitor styles manufactured during each 2-month or 6-month period, as applicable, shall be represented, as far as practical, in at least the approximate ratio of production.

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 Subgroups 1 through 4. Forty-six sample units shall be taken from production every 6 months and subjected to the applicable tests for their particular subgroup. Permitted failures shall be as specified in table VII.

TABLE VII. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted 1/
Every 6 months				
Subgroup 1				
Vibration, high frequency	3.15	4.7.11	18	1
Immersion	3.16	4.7.12		
Subgroup 2				
Shock, specified pulse	3.17	4.7.13	18 3/	1 1
Terminal strength 2/	3.18	4.7.14		
Resistance to soldering heat	3.11	4.7.7		
Moisture resistance	3.19	4.7.15		
Subgroup 3				
Voltage-temperature limits 4/	3.14	4.7.10	6	1
Low temperature storage	3.23	4.7.19		
Marking legibility (laser marking only)	3.25.1	4.7.1.1		
Subgroup 4				
Resistance to solvents	3.21	4.7.17	4 5/	0
Every 2 months				
Subgroup 5				
Life (at elevated ambient temperature)	3.22	4.7.18	10 minimum per style	See 4.6.2.1.1.2
Partial discharge	3.10	4.7.6		

1/ A sample unit having one or more defects shall be charged as a single defective.
2/ Applicable unless otherwise specified, (see 3.1).
3/ Samples shall be representative of the highest capacitance value of each style manufactured during the sampling period.
4/ Samples shall be selected from a minimum of two lots per sampling period when more than one lot of dielectric is used.
5/ When more than one marking type is used (see 3.21), an additional four samples shall be added for each additional marking type.

4.6.2.1.1.2 Subgroup 5. A minimum of 10 sample units of the highest capacitance value per style produced shall be selected from each inspection lot produced during a 2-month period. The actual number of samples selected shall be such that the number of unit hours generated meet the maintenance period requirements of MIL-STD-690 for the qualified failure rate level. Permitted failures shall be as specified in MIL-STD-690. The acculumated data shall be used for maintenance and extension of failure rate qualification.

4.6.2.1.2 Disposition of sample units. Sample units which have been subjected to group B inspection shall not be delivered on the contract.

4.6.3 Noncompliance. If a sample unit fails to pass group B inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed), at the option of the qualifying activity. Group A inspection may be reinstituted; however, final acceptance shall be withheld until the group B inspection has shown that corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.6.4 Inspection of packaging. The sampling and inspection of the preservation, packing, and container marking shall be in accordance with the requirements of MIL-C-39028.

4.7 Methods of examination and test.

4.7.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements. (See 3.1, 3.4, 3.4.1, 3.5, 3.25, and 3.26.)

4.7.1.1 Marking legibility (laser marking only, see 3.25.1). Capacitors shall be coated with 0.005 (.13 mm) minimum of silicone resin (SR) insulating compound, type SR of MIL-I-46058. After curing, coated capacitors shall be examined for legibility under normal production room lighting by an inspector with normal or corrected 20/20 vision.

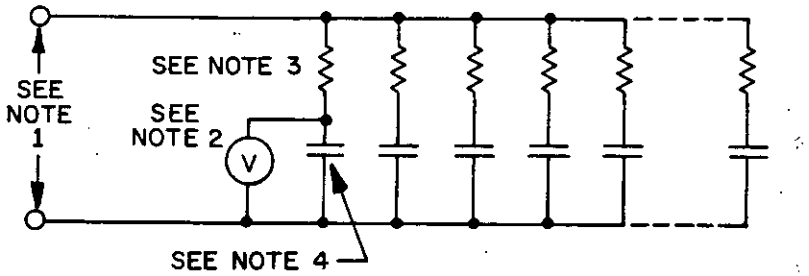
4.7.2 Thermal shock and voltage conditioning (see 3.6). Capacitors shall be subjected to the tests of 4.7.2.1 and 4.7.2.2, as applicable (see tables IV and V).

4.7.2.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following detail and exception shall apply:

a. Test condition: A, except that in step 3, sample units shall be tested at +125°C.

b. Measurement after cycling: Dielectric withstanding voltage as specified in 4.7.5.

4.7.2.2 Voltage conditioning. Voltage conditioning shall be started immediately after completion of the thermal shock test. The voltage conditioning shall consist of applying rated voltage to the units at +125°C +4°C, -0°C for 96 hours minimum. Voltage shall be applied and shall reach maximum value within 30 seconds. To assure that at least 95 percent of the applied test voltage is maintained for the duration of the test period, the circuit on figure 2 shall be used.



NOTES:
1. The power supply shall be capable of providing a minimum of twice the rated voltage of the capacitors at five times the current requirement of the circuit.
2. There shall be a voltage monitor that will trigger an alarm and shut off the test if the applied voltage drops or increases by more that 5 percent. The resistance of the voltage monitor shall be a minimum of 10 times the equivalent resistance of the capacitors.
3. The current limiting device shall be a resistor. For 1000 V dc tests the resistor shall be 1 megohm ±10 percent. For tests above 1000 V dc, the resistor shall be 100 megohm maximum.
4. There is no minimum number of capacitors in the capacitor bank.

FIGURE 2. Voltage conditioning circuit.

After completion of the test period, with the capacitors maintained at the +125°C test temperature, and before removal of the test voltage, the insulation resistance shall be measured at rated voltage. The units shall then be allowed to stabilize at room temperature (+25°C). After stabilization at room temperature, the insulation resistance shall be measured as specified in 4.7.8. After measurement of insulation resistance at +25°C, the capacitance and dissipation factor shall be measured as specified in 4.7.3 and 4.7.4, respectively.

4.7.3 Capacitance (see 3.7). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following detail and exception shall apply:

a. Test frequency: 1 megahertz ±100 kHz when the nominal capacitance is 100 pF or less, and 1 kHz ±100 Hz when the nominal capacitance is greater than 100 pF.
b. Voltage: A root-mean-square potential of 1.0 ±0.2 volts, when no polarizing voltage.

Note: Following a dielectric withstanding voltage or insulation resistance test, capacitance measurement for capacitors with BR or BZ voltage-temperature coefficients may be delayed for a period of up to 24 hours.

4.7.4 Dissipation factor (see 3.8). Unless otherwise specified (see 3.1), the dissipation factor shall be measured with a capacitance bridge or other suitable method at the frequency and voltage as specified in 4.7.3a and b. The inherent accuracy of the measurement shall be ±2 percent of the reading plus 0.1 percent dissipation factor (absolute) unless otherwise specified. Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the capacitor.

4.7.5 Dielectric withstanding voltage (see 3.9).

4.7.5.1 Dielectric. Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

a. Magnitude and nature of test voltage: Unless otherwise specified (see 3.1), 150 percent of dc rated voltage shall be applied for 1250 volts or less, and 120 percent of dc rated voltage shall be applied for 1251 volts and higher. It is recommended that the capacitors be immersed in an inert medium, such as freon, to prevent arcing or high leakage currents.
b. Duration of application of test voltage: 1 second minimum. The test voltage shall be raised from 0 to the specified value within 1 minute, maximum.
c. Points of application of test voltage: Unless otherwise specified (see 3.1), between the capacitor-element terminals.
d. Limiting value of surge current: 30 to 50 mA for 1250 volts or less, and 10 mA maximum for 1251 volts and higher.
e. Examination after test: Capacitors shall be examined for evidence of damage and breakdown.

4.7.5.2 Body insulation. Capacitors shall be tested at 1000 V dc.

a. Points of application of test voltage: Unless otherwise specified (see 3.1), capacitors shall be wrapped with a conductive tape or foil so that the tape or foil shall not be less than .100 (2.54 mm) and more than .150 (3.81 mm) away from the lead wires. The dc potential shall be applied between the two leads connected together and the tape or foil for a period of 5 ±1 second. The test circuit shall be so arranged that the surge current does not exceed 30 mA.

4.7.6 Partial discharge (corona) (see 3.10). Capacitors shall be tested in accordance with appendix B.

4.7.7 Resistance to soldering heat (see 3.11). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply.

a. Special preparation of the specimen: The parts shall be adequately preheated or heat sinks shall be used on each lead during the test. Both leads shall be dipped in RMA flux in accordance with MIL-F-14256, and then dipped into solder, both for 5 ±.5 second. The bath shall be maintained at +260°C ±5°C. The parts shall be immersed to within .075 (1.90 mm) ±.025 (0.64 mm) of the body.
b. Test condition: C.
c. Post test conditioning: The capacitors shall be inserted in a vapor degreasing apparatus containing boiling 1-1-1 trichloroethane for 1 1/2 to 2 minutes. The parts shall then be cleaned with isopropyl alcohol.
d. Measurements after test: After completion of the cleaning process and following a minimum 3-hour cooling period, the capacitance, dissipation factor, dielectric withstanding voltage, and insulation resistance shall be measured as specified in 4.7.3, 4.7.4, 4.7.5, and 4.7.8, respectively.
e. Examination after test: Capacitors shall be examined for evidence of mechanical damage.

4.7.8 Insulation resistance (see 3.12). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

a. Test potential: 500 V dc.
b. Special conditions: If a failure occurs at a relative humidity of 50 percent or higher, the insulation resistance may be measured again at a relative humidity of less than 50 percent.
c. Points of measurement: Unless otherwise specified (see 3.1), between the capacitor-element terminals.
d. Surge current: Limited to 30 mA.

4.7.9 Solderability (see 3.13). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following detail shall apply:

a. Number of terminations to be tested: 2 (unless othewise specified (see 3.1)).

4.7.10 Voltage-temperature limits (see 3.14).

4.7.10.1 For qualification inspection. The temperature of each capacitor shall be varied as specified in table VIII. Capacitance measurements shall be made at the frequency and voltage specified in 4.7.3a and b. The voltage specified in table VIII shall be maintained on the capacitor during steps E to G inclusive. Capacitance measurements shall be made at each step specified in table VIII and at a sufficient number of intermediate temperatures, between steps B and G to establish a true characteristic curve. Capacitors shall be kept at each temperature until temperature equilibrium is attained.

NOTE: An approved alternate test method based on volts/mil stress of the same dielectric lot may be used.

4.7.10.2 For quality conformance inspection. Capacitance measurements shall be made as specified in 4.7.10.1 with the following exceptions:

a. Measurments shall be made only for steps C, D, E, and G of table VIII.
b. Temperature characteristic BZ shall be measured at 60 percent of rated voltage.

TABLE VIII. Voltage-temperature limit cycle.

Step	Voltage, dc	Temperature
		°C ±2°C
A	None	+25
B	None	-55
C 1/	None	+25
D	None	+125
E	See 3.1	+125
F	See 3.1	+25
G	See 3.1	-55

1/ Reference point.

4.7.11 Vibration, high frequency (see 3.15). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exception shall apply:

a. Mounting: Capacitors shall be rigidly mounted on a mounting fixture by the body. Leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately .375 (9.52 mm) when measured from the edge of the supporting terminal. Leads shall be within 15° of being parallel. When securing leads, care shall be taken to avoid pinching the leads. The mounting fixture shall be so constructed as to preclude any resonances within the test range. An examination of the mounting fixture shall be made on a vibrator. If any resonsant frequencies are observed, adequate steps must be taken to damp the structure.
b. Electrical-load conditions: During the test, minimum test voltage of 200 V dc shall be applied between the terminals of the capacitor element under test.
c. Test condition: D (20 G's).
d. Duration and direction of motion: Equal amounts of time in each of three mutually perpendicular planes (total of 8 hours).
e. Measurements during vibration: During the last cycle in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration, or open-circuiting or short-circuiting.
f. Examination after vibration: Capacitors shall be visually examined for evidence of mechanical damage.

4.7.12 Immersion (see 3.16). Capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

a. Test condition: B.
b. Examinations and measurments after final cycle: Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking; dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor shall then be measured as specified in 4.7.5, 4.7.8, 4.7.3, and 4.7.4, respectively.

4.7.13 Shock, specified pulse (see 3.17). Capacitors shall be tested in accordance with method 213 of MIL-STD-202. The following details shall apply:

a. Mounting: Capacitors shall be rigidly mounted by the body.
b. Test condition: I (100 G's).
c. Measurements during shock: During the last shock in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration, or open-circuiting or short-circuiting.
d. Examination after shock: Capacitors shall be visually examined for evidence of breakdown, arcing, and mechanical damage.

4.7.14 Terminal strength, when applicable (see 3.18). Capacitors shall be tested in accordance with method 211, MIL-STD-202. The following details and exceptions shall apply:

a. Test condition: A.
b. Applied force: 5 pounds.
c. Examination after test: Capacitors shall be visually examined for evidence of loosening or rupturing of the terminals.

4.7.15 Moisture resistance (see 3.19). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Initial measurements: Not applicable.
b. Number of cycles: Twenty continuous cycles.
c. Step 7b: Not applicable.
d. Loading: During the first 10 cycles only, a dc potential of 1000 volts shall be applied across the capacitor terminals. Once each day, a check shall be performed to determine whether a capacitor has shorted.
e. Examinations and final measurement: On completion of step 6 of the final cycle, capacitors shall be conditioned at +25°C ±5°C and a relative humidity of 50 percent ±5 percent for a period of 18 hours minimum, 24 hours maximum, and shall be visually examined for evidence of mechanical damage and obliteration of marking; capacitance, dielectric withstanding voltage, and insulation resistance shall then be measured as specified in 4.7.3, 4.7.5, and 4.7.8, respectively.

4.7.16 Fungus (when applicable, see 3.20). Capacitors shall be tested in accordance with method 508 of MIL-STD-810.

4.7.17 Resistance to solvents (see 3.21). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

a. The marked portion of the capacitor body shall be brushed.
b. Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking.

4.7.18 Life (at elevated ambient temperature) (see 3.22). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

a. Distance of temperature measurements from specimens, in inches: Not applicable.
b. Test temperature and tolerance: +125°C, +4°, -0°C.
c. Operating conditions: Capacitors shall be subjected to the rated voltage, ±5 percent. The test voltage shall be raised from zero to the rated value, ±5 percent, within 1 minute maximum. Test circuitry shall be the same as that required for voltage conditioning (see 4.7.2.2).

d. Test condition: 2,000 hours elapsed time for qualification inspection with all samples continued to 10,000 hours; 10,000 hours for failure rate level inspection of group B.
e. Measurements during and after exposure: Insulation resistance shall be measured during exposure by the method specified in 4.7.2.2. Measurements shall be taken at:

0 hours; 250 +48, -0 hours; 1,000 +48, -0 hours; 2,000 +96, -0 hours; and every 2,000 +96, -0 hours thereafter until the required 10,000 hours have elasped.

After exposure, the insulation resistance, capacitance, and dissipation factor shall be measured as specified in 4.7.8, 4.7.3, and 4.7.4, respectively.

4.7.19 Low temperature storage (see 3.23). Capacitors shall be subjected to exposure at -65°C +0°C, -3°C for a period of 8 hours, minimum.

4.7.20 Radiographic inspection (swaged leads only) (see 3.24). Capacitors shall be tested in accordance with method 209 of MIL-STD-202. The following details and exception shall apply:

a. Radiographic quality: The radiograph shall render a clear, sharp image of the penetrameter.
b. Image-quality indicator: A radiograph of the penetrameter shall be included on each radiograph film. The penetrameter may be made from a sample capacitor, of the same style as the capacitor being radiographed, with an AWG number 48 copper wire mounted across the capacitor body or it may be fabricated in accordance with, or be equivalent to, the example in figure 3.
c. Positions of specimen: Unless otherwise specified (see 6.2), one view shall be taken of each capacitor perpendicular to the plane of the lead surface (see figure 4).
d. Evaluation of images:
   (1) Special kind of viewing equipment: Magnifying glass.
   (2) Magnification: 10X.
   (3) Defects to be sought in specimen: As specified in 3.24.
e. Additional required examination:
   (1) There shall be a minimum of 80 percent solder fillet between capacitor element and each lead.
   (2) There shall be a minimum of .005 (0.127 mm) encapsulating material encasing the capacitor element (see figure 5).
   (3) There shall be a minimum of .005 (0.127 mm) between edge of case and tip of solder spike.
   (4) Extraneous particles or void in encapsulating material shall not be greater than .005 (0.127 mm) in any dimension.

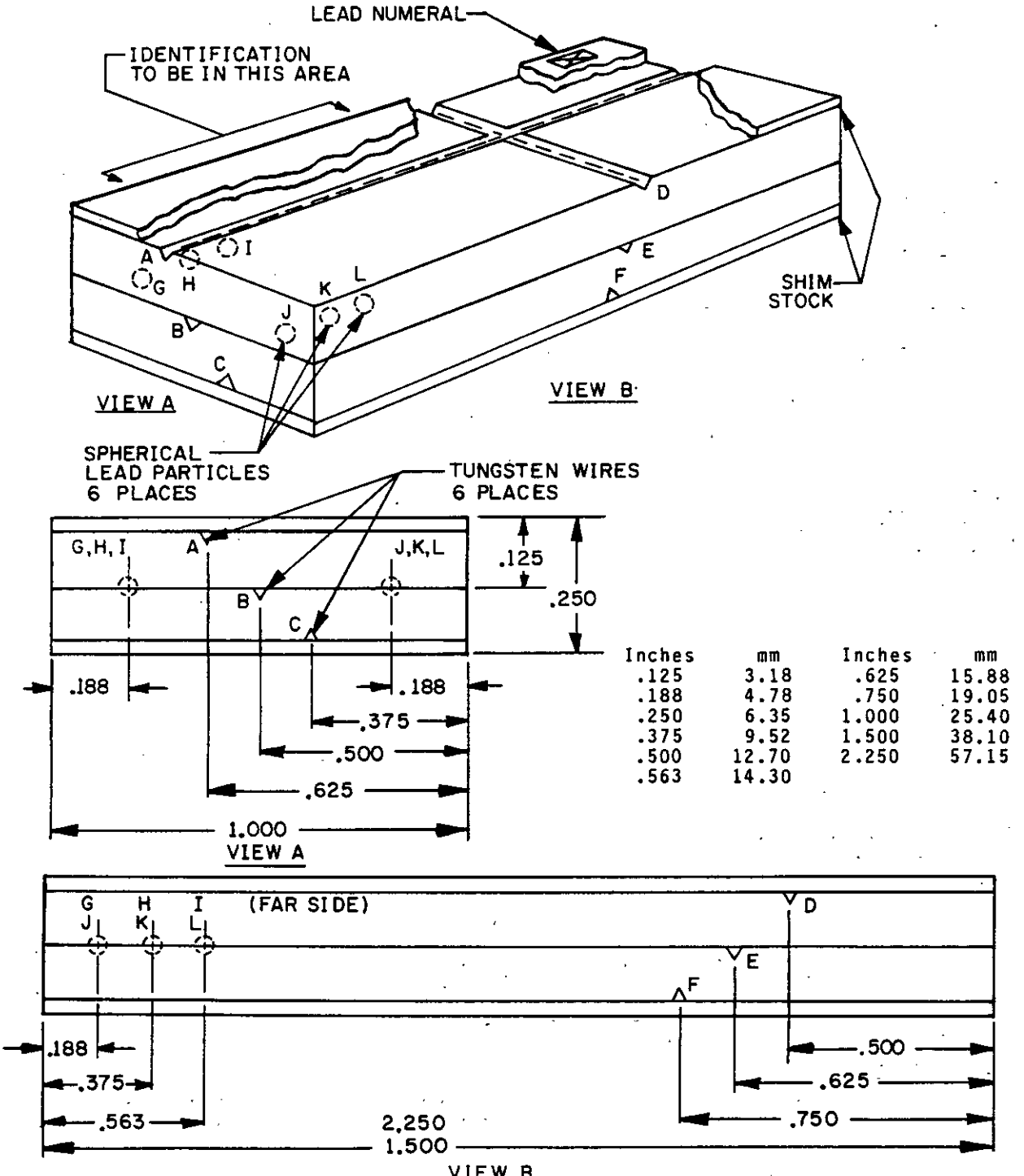
NOTE: Test results (covering the number of capacitors tested with number and kinds of failure noted) and radiograph shall be retained for a minimum period of 2 years. Upon request of user, this data shall be supplied with each shipment.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-C-39028.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory).



Inches	mm	Inches	mm
.125	3.18	.625	15.88
.188	4.78	.750	19.05
.250	6.35	1.000	25.40
.375	9.52	1.500	38.10
.500	12.70	2.250	57.15
.563	14.30		

FIGURE 3. Image quality indicator (optional).

Table of image quality indicators

Tungsten wire diameters						Lead particle diameters						Steel shim stock
A	B	C	D	E	F	G	H	I	J	K	L	
.002 (0.05)	.001 (0.03)	.0005 (0.013)	.0005 (0.013)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	None
.002 (0.05)	.001 (0.03)	.0005 (0.013)	.0005 (0.013)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.002 (0.05)
.002 (0.05)	.001 (0.03)	.0005 (0.013)	.0005 (0.013)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.005 (0.13)
.002 (0.05)	.001 (0.03)	.0005 (0.013)	.0005 (0.013)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.007 (0.18)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.010 (0.25)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.015 (0.38)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.025 (0.64)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.035 (0.89)

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Wires to be tungsten, shim stock to be carbon steel, particles to be lead. Center section to be .125 inch (3.18 mm) layers of clear acrylic plastic, bonded with clear plastic cement of low X-ray density. Fasteners may be used within .250 inch (6.35 mm) from each corner, but shall not interfere with end use of the penetrameter. Bottom surface shall be flush.
4. All dimensions shown are ±.005 inch (0.13 mm), except wires and shim stock, which shall be within standard mil tolerances, and lead particles, which shall be ±.0002 inch (0.005 mm). Groove details are not critical except that wire must be embedded flush or below surface of plastic and centered at the location shown. Particle-hole sizes are not critical, but should not exceed .031 inch (0.79 mm) in diameter and depth, and must be centered as shown, ±.005 inch (0.13 mm).
5. Additional layers of shim stock may be used as necessary.
6. Identification marking shall be permanent and legible. Location and size of characters are not critical but shall not interfere with or obscure the radiographic image details.

FIGURE 3. Image quality indicator (optional) - Continued.

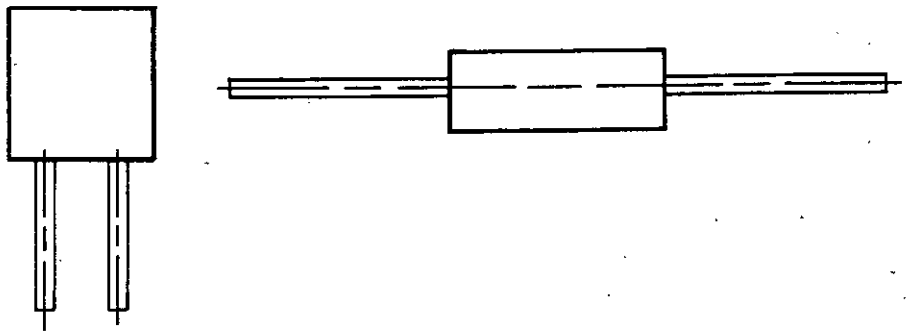
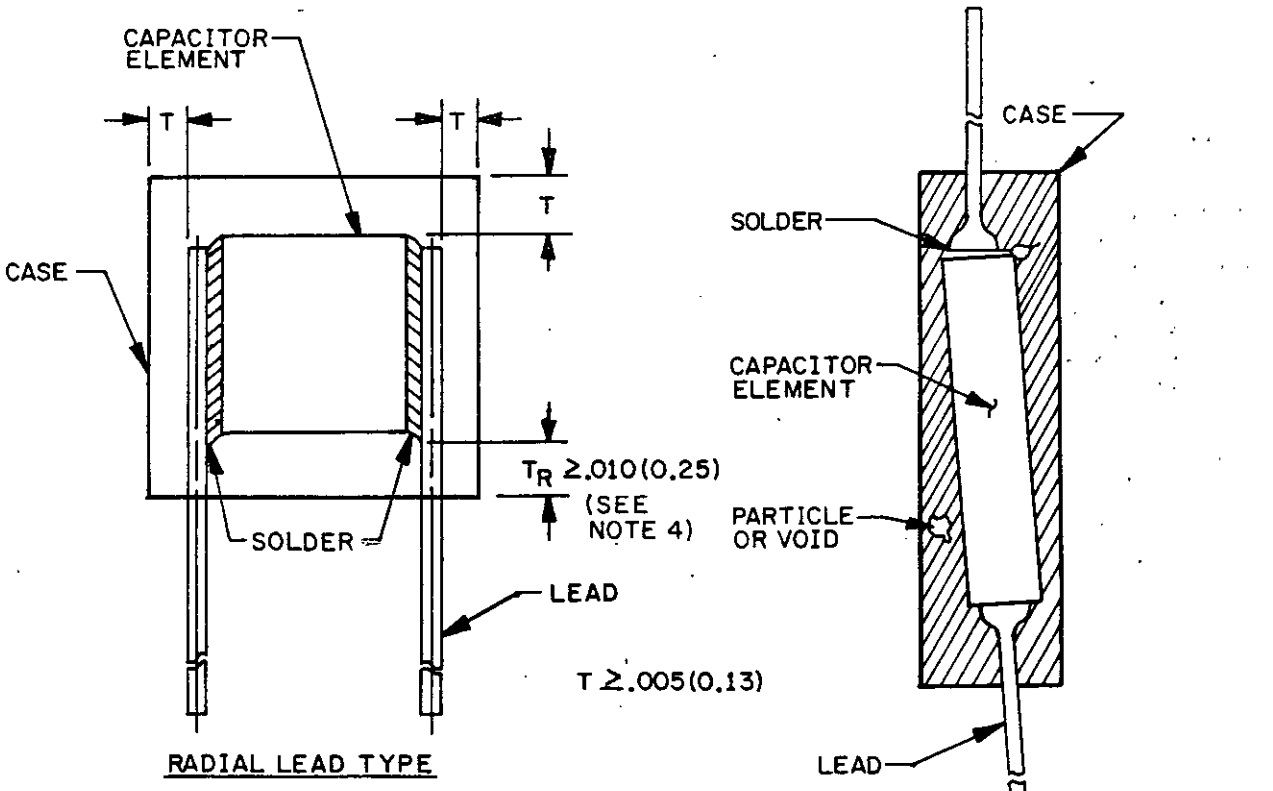


FIGURE 4. Viewing planes for radiographic inspection.



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Millimeters are in parentheses.
4. T_R is measured to the point at which the lead diameters are increased above their nominal dimension by the solder meniscus.

FIGURE 5. Radiographic inspection criteria.

6.1 Intended use. These capacitors are primarily designed for use where a small physical size with comparatively large electrical capacitance and high insulation resistance is required. General purpose (BR and BZ characteristics) ceramic capacitors are not intended for frequency-determining or precision circuits but are suitable for use as by-pass, filter, and noncritical coupling elements in high-frequency circuits. All of these applications are of the type where dissipation factor is not critical, and moderate changes due to temperature, voltage, and frequency variations do not effect the proper functioning of the circuit. BP characteristic ceramic capacitors are for use in critical frequency determining applications, timing circuits, and other applications where absolute stability is required.

6.1.1 Case insulation. It is not intended that the case insulation be subjected to sustained voltage in excess of 500 volts. Supplementary insulation should be provided where the case may come in contact with higher voltage or a ground.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification.
b. Issue of DODISS to be cited in the solicitation, and, if required, the specific issue of individual documents referenced (see 2.1).
c. Required number of views and planes if other than that specified (see 4.7.20c).

6.3 Qualification. With respect to products requiring qualfication, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the U.S. Army Laboratory Command, Attn: SLCET-R-S, Fort Monmouth, NJ 07703; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444. Application for qualfication tests shall be made in accordance with SD-6, "Provisions Governing Qualification" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.4 FR level substitutability data (see 3.1). Lower FR level items covered under current specification sheets are substitutable for all higher FR level items covered under superseded specification sheets as indicated below:

FR level	Will substitute for FR levels
S	R, P, M
R	P, M
P	M

6.5 Application caution. Additional encapsulation is necessary in applications where the possibility of a voltage breakdown between leads of the capacitor, or the capacitor to another potential could occur.

6.5.1 Soldering installation or removal. Heat sinks on each lead or adequate preheating is required when these capacitors are installed in or removed from circuits by soldering iron.

6.6 Subject term (key word) listing.

Capacitor
Ceramic
Established reliabilty
High voltage
Multilayered

APPENDIX A

PROCEDURE FOR QUALIFICATION INSPECTION

10. SCOPE

10.1 This appendix details the procedure for submission of samples, with related data, for qualification inspection of capacitors covered by this specification. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. SUBMISSION

30.1 Sample.

30.1.1 Single-style submission. A sample of the size required in table IV, of the highest capacitance value in each voltage rating in each operating temperature range and voltage-temperature limit in each style for which qualification is sought shall be submitted.

30.2 Test data. When examinations and tests are to be performed at a Government laboratory, prior to submission, all sample units shall be subjected to all of the examinations and tests indicated as nondestructive in table IV. Each submission shall be accompanied by the test data obtained from these examinations and tests. The performance of the destructive tests by the contractor on a duplicate set of sample units is encouraged, although not required. All test data shall be submitted in duplicate.

30.3 Certification of material. When submitting samples for qualification, the contractor shall submit cerification, in duplicate, that the materials used in his components are in accordance with the applicable specification requirements.

30.4 Description of items. The contractor shall submit a detailed description of the capacitors being submitted for inspection, including body, coating, electrode material, terminal leads, etc.

40. EXTENT OF QUALIFICATION

40.1 Single-style submission. Capacitance-range qualfication will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerance equal to and wider than the tolerance submitted. DC rated voltage qualification will be restricted to that submitted. Operating temperature range and voltage temperature limit qualification will be restricted to that submitted. Qualification shall be performed only on units specifically designed to this specification. Approval shall not be allowed by similarity to low voltage units.

APPENDIX B

AC PARTIAL DISCHARGE (CORONA) TEST

10. SCOPE

10.1 Scope. This appendix details the detection and measurement of partial discharge (corona) under ac applied voltage as required in 3.10 and 4.7.6. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. REQUIREMENTS AND DEFINITIONS

30.1 Supply voltage. The supply voltage for ac partial discharge tests shall be variable ac voltage at a frequency of 60 Hz ±5 percent and shall be measured in ac volts rms with a tolerance of ±5 percent of the ac test voltage.

30.2 Sensitivity. The partial discharge detection system's sensitivity depends on the capacitance of the test specimen. The test specimen shall be connected during system calibration and the sensitivity requirements shall be: For capacitance less than or equal to .005 µF, system sensitivity shall be able to detect 5 picocoulomb (pC) or less. For capacitance above .005 µF to and including 0.1 µF, system sensitivity shall be able to detect 15 pC or less. For capacitance greater than 0.1 µF up to 0.47 µF the sensitivity shall be 50 pC or less. A calibration signal injection capacitor shall be connected in parallel during calibration.

30.3 Corona inception voltage. Corona inception voltage (CIV) at a given pC level shall be defined as the voltage at which continuous partial discharges can be recorded at that pC level. This is above the minimum sensitivity, as the applied voltage is increased at a constant rate.

30.4 Corona extinction voltage. Corona extinction voltage (CEV) at a given pC level is defined as the voltage at which continuous partial discharges at that level disappear as the voltage is decreased from the inception voltage.

40. TEST CONDITIONS AND PROCEDURE

40.1 Deaging. The set of capacitors to be tested shall be deaged by heating them with the leads shorted together, for 12 hours at +85°C and standard pressure, as follows:

40.2 Connection. The capacitor under test shall be connected between the high voltage terminal and ground of the detection system with insulated, corona-free cables. The capacitor, its leads and bare metal connecting clips shall be immersed in FC-40 or FC-43 dielectric fluid (fluorinert) or equivalent.

40.3 System calibration. The system shall then be calibrated according to requirements of 30.2. The calibration injection capacitor shall then be removed.

40.4 Application of voltage. The applied voltage shall then be increased at a constant rate of approximately 0.2 kV rms/second. The maximum test voltage shall not be more than 70 percent of the V rms value where the V rms value is $1/\sqrt{2}$ times the dc rated voltage of the capacitor under test. Maximum test voltage = 0.5 x dc rated voltage.

40.5 Measurement. When the voltage is increased as in 40.4, the increase shall be stopped when the observed corona pulses reach 100 pC amplitude for the most energetic ones and, if they persist, the voltage shall be recorded as the corona inception voltage (CIV). The voltage shall then be immediately decreased so that the dwell time at CIV is no longer than 5 seconds. The CIV shall never be exceeded. As the voltage is decreased, the corona extinction voltage (CEV) shall be observed and recorded. The voltage shall then be decreased to 0 volts.

40.6 Recordings. For the qualification and group B inspection, the sample serial numbers, the CIV, the maximum corona magnitude, and the CEV shall be recorded for each part tested.

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 85
NASA - NA

Review activities:
Army - MI
Air Force - 11, 99
DLA - ES

User activities:
Army - AT, AV, ME
Navy - MC
Air Force - 19

Preparing activity:
Army - ER

Agent:
DLA - ES

(Project 5910-1614)

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-C-49467	Capacitors, Fixed, Ceramic, Multilayer, High Voltage (General Purpose), Established Reliability

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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